# FORESTRY RESEARCH

WHAT'S NEW IN THE WEST DEC. 1975
U.S. Department of Agriculture Forest Service

# a note to you

In the Fall of 1973, we published our first issue of *Forestry Research: What's New in the West.* Our intent with that first issue, as it is now, is to let you know about the work being done at the USDA Forest Service's Intermountain, Pacific Northwest, Pacific Southwest, and Rocky Mountain Experiment Stations. Whether you are a natural resource manager in a public agency or in private industry, or are in a profession other than forestry but want to keep up with this field, our goal is to inform you of (1) current major research programs; and (2) new findings from our work.

Your comments and suggestions for making *Forestry Research* effective in serving you are requested. Please pass the publication on to others who may be interested.

# on the cover

This stream gage at Woods Canyon in Arizona's Coconino National Forest will be used to monitor streamflow changes resulting from resource management experiments. See "More Water for Arizona?" on the facing page.

# our addresses

Single copies of most of the publications mentioned in this issue are available free of charge. When writing to research Stations, please include your complete mailing address (with ZIP) and request publications by author, title, and number (if one is given).

For INT publications write:

Intermountain Forest and Range Experiment Station
507 25th Street
Ogden, Utah 84401

For PSW publications write:

Pacific Southwest Forest and Range Experiment Station
Post Office Box 245
Berkeley, California 94701

For PNW publications write:

Pacific Northwest Forest and Range Experiment Station
Post Office Box 3141
Portland, Oregon 97208

For RM publications write:

Rocky Mountain Forest and Range Experiment Station
240 West Prospect Street
Fort Collins, Colorado 80521

If you are planning to move, please notify us as much in advance as possible. Send your old address, your new address, and the address label from the back cover to *Forestry Research: What's New in the West,* 240 West Prospect Street, Fort Collins, Colorado 80521

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# More water for Arizona?

Arizonans use 7 million acre-feet of water each year for agriculture, industries, and municipalities. Of the total, 2 million acre-feet come from streamflow; the rest are pumped from ground water supplies—exceeding their recharge by 2 to 3 million acre-feet each year.

So, water tables are dropping. Drops of 6 to 10 feet per year are not uncommon, particularly in the intense agricultural and metropolitan areas of Phoenix and Tucson. Arizona's population, currently about 2,200,000, is projected to be nearly 3,000,000 by 1985. Demands for water will increase!

Arizonans see two ways to partially alleviate their water problems: (1) import Colorado River water through a massive diversion system known as the Central Arizona Project; and (2) increase surface streamflow by reducing the amount of water used by natural vegetation.

In the late 1950's, concerned citizens asked the Rocky Mountain Forest and Range Experiment Station and the Southwestern Region of the Forest Service to find out how much water might realistically be gained by altering vegetation along streams and on mountain watersheds. The U.S. Geological Survey undertook similar studies on more arid lands.

Planning the mountain watershed studies required close coordination among researchers and Forest Service land managers. Both groups realized water yield improvement could not be the sole objective of the research: Though Arizonans expressed concern for water, they also wanted other resources—timber, recreation experiences, scenic beauty, habitat for wildlife , and forage for livestock.

For this reason, research programs were designed to find ways to improve water yield as well

▼ Watershed research in Arizona has included vegetation types from streamside to mountaintop.

as to evaluate the impacts of watershed management practices on other resources. Economic costs and benefits were to be analyzed.

It was also decided studies, except for statewide investigations on streamside vegetation, would focus on the 8.4 million acres within the Salt and Verde River drainages of central Arizona. These drainages supply Phoenix and the Salt River Valley—the heaviest water-using sector of the State.

What have we learned from nearly 20 years of this research? Scientists at Rocky Mountain Station laboratories in Arizona recently published summaries of the results of their studies so far. In general, they concluded: (1) water yield from certain vegetation types can be increased, but tradeoffs with other resource values must be thoroughly understood before water-yield-improvement programs are undertaken; and (2) significant environmental and economic consequences likely to result from alternative watershed management programs can be predicted before action is taken. These facts make sound decisions for vegetation treatment possible.

Research results suggest the following potential increases in water yield from the vegetation types studied:

## *Mixed conifer, ponderosa pine*

Though mixed conifer forests occupy only 0.4 percent of Arizona, they supply 6 percent of the streamflow. By applying a system of patchcutting wherever harvesting is permitted, it appears about 20,000 acre-feet of additional water from the Salt-Verde Basin can be delivered to users annually. By cutting small openings over one-sixth of the forest every 20 years, wildlife habitat and grazing resources can be improved along with water yield.

Water yield research in ponderosa pine has been conducted mostly on volcanic soils. These soils underlie 57 percent of the ponderosa pine forests in the Salt-Verde Basin. From them, an average net increase of 23,000 acre-feet of surface runoff appears feasible. Smaller increases may also be possible from forests growing on more porous sedimentary soils. More research is needed here.

These studies also demonstrate that management programs can be designed to produce significant improvement in timber, livestock forage, big game habitat, and esthetic benefits as well as water increases. Further, such improvements can be achieved with reasonably small increases in management and treatment costs, if sufficient attention is paid to quality control.

▲ Prescribed fire may help increase streamflow.

## *Pinyon-juniper, chaparral*

In the pinyon-juniper type, little water-yield increase was realized, even with extensive tree removal. One exception was where trees were killed by chemicals and left standing. Current environmental constraints, however, probably rule out this type of treatment.

The most notable benefit from pinyon-juniper removal was increased forage for livestock. Even so, in only the most successful conversion experiments did economic benefits equal the cost of doing the job.

Chaparral studies suggest small irregular patches be converted to grass wherever steep slopes, wilderness, special scenic values, or other constraints do not prohibit this treatment. For areas where conversion is environmentally safe, and benefits exceed costs, there is a potential to augment net water yield by 30,000 acre-feet per year in the Salt-Verde Basin. Erosion may increase during early years following conversion. Long-term erosion is reduced, however, because grass provides better soil protection than chaparral. Successful conversions increase livestock forage and food for wildlife, and add visual variety to the landscape.

Studies on streamside shrubs and trees suggest about 33 percent of the land supporting this vegetation in Arizona can be treated to convert plants that are heavy users of water to other types. Included in this figure are lands both within and outside of the Salt-Verde Basin. By applying appropriate treatments, about 130,000 acre-feet of water could be salvaged State-wide annually. Most of the treatable areas are along the Colorado and lower Gila Rivers.

Where conversion is being planned, researchers recommend that variety in plants be retained, so that multiple-use values and visual diversity can be achieved.

In total, research findings suggest approximately 73,000 acre-feet of water might be added to the average annual streamflow within the Salt-Verde Basin through careful management of mountain watersheds. Additional increases in Arizona's water supply may be realized from other river basins, particularly in chaparral, ponderosa pine, and mixed conifer country. However, more data is needed from these areas before reliable estimates can be made.

Also, 130,000 acre-feet might be salvaged each year by modification of streamside vegetation throughout the state.

## Mix of uses

Researchers believe these increases are possible without detrimental impacts on other resources. In fact, environmental diversity and productivity may be enhanced by proper watershed treatment.

These findings, however, do not mean public lands will be managed primarily to obtain increased water yield. Management of some areas may well favor other resources of higher value, with any water yield improvements coming as a byproduct.

Land managers and concerned publics are working together to determine the most beneficial mix of uses for Arizona's public lands. Research is providing data on water yield potential, the effects of watershed management on other resources, and the costs and benefits of water yield improvement programs.

Where is Arizona watershed research headed? The Rocky Mountain Station has turned most of its studies on streamside vegetation over to other agencies. Ponderosa pine and pinyon-juniper work at the Station's Flagstaff Laboratory, and mixed conifer and chaparral investigations at its Tempe location, are being re-directed to evaluate the consequences of all types of natural resource management on all affected resources. Working together, scientists, economists, and resource managers are formulating mathematical models to simulate future results of alternative land management programs. (For more information on this new research direction, read "Tools for Land-use Planning" in the February, 1975, issue of *Forestry Research: What's New in the West.*)

## Reports available

For detailed results of Arizona watershed research, write to the Rocky Mountain Station, Fort Collins, Colorado, for any of the following papers:

Horton, Jerome S., and C. J. Campbell, 1974. Management of Phreatophyte and Riparian Vegetation for Maximum Multiple Use Values. USDA Forest Serv. Res. Pap. RM-117-FR5. 23 p.

Hibbert, Alden R., Edwin A. Davis, and David G. Scholl. 1974. Chaparral Conversion Potential in Arizona. Part I: Water Yield Response and Effects on Other Resources. USDA Forest Serv. Res. Pap. RM-126-FR5. 36 p.

Brown, Thomas C., Paul F. O'Connell, and Alden R. Hibbert. 1974. Chaparral Conversion Potential in Arizona. Part II: An Economic Analysis. USDA Forest Serv. Res. Pap. RM-127-FR5. 28 p.

Clary, Warren P., Malchus B. Baker, Jr., Paul F. O'Connell, Thomas N. Johnsen, Jr., and Ralph E. Campbell. 1974. Effects of Pinyon-juniper Removal on Natural Resource Products and Uses in Arizona. USDA Forest Serv. Res. Pap. RM-128-FR5. 28 p.

Brown, Harry E., Malchus B. Baker, James L. Rogers, Warren P. Clary, J. L. Kovner, Frederic R. Larson, Charles C. Avery, and Ralph E. Campbell. 1974. Opportunities for Increasing Water Yields and Other Multiple Use Values on Ponderosa Pine Forest Lands. USDA Forest Serv. Res. Pap. RM-129-FR5. 36 p.

Rich, Lowell R., and J. R. Thompson. 1974. Watershed Management in Arizona's Mixed Conifer Forests: The Status of Our Knowledge. USDA Forest Serv. Res. Pap. RM-130-FR5. 15 p.

*—By Phil Johnson, Rocky Mountain Station*

# Managing true fir in California

Red fir and white fir of high-elevation California forests are among the most important timber types in the State—for production of wood, protection of snow-zone watersheds, and enhancement of recreation areas. But management of true fir forests presents many problems. One of the most pressing is how to get good natural or artificial regeneration after old-growth stands have been logged.

▼ Logging of overstory released these young trees.

Researchers of the Pacific Southwest Forest and Range Experiment Station are working on this and other aspects of true fir management in California. Some studies have been under way for a long time: Station research on red and white fir at the Swain Mountain Experimental Forest in northeastern California and Stanislaus Experimental Forest in the central Sierra Nevada, for example, started in the 1950's. Other experiments are much newer, initiated in response to the current need for answers to such questions as how to raise sturdier seedlings in the nursery, or how to stock young-growth stands for maximum timber yield.

For the past 15 years, research forester Donald T. Gordon of the Station's Redding, California, unit, has specialized in research on true fir. Gordon is currently experimenting with shelterwood cuttings and small clearcuttings at Swain Mountain. From the shelterwood study, he wants to determine how many trees should be left to get adequate natural regeneration, and how to log the shelterwood stand without damaging seedlings. The shelterwood study plots have 10, 20, and 30 leave-trees per acre.

On the clearcut sites, Gordon wants to see how the size of a clearcut opening, and the orientation of the cutting edge (toward or away from the wind) affect natural regeneration in the openings and wind damage to the stands surrounding these clearings. His approach has been to enlarge the size of 2- and 3-chain wide strips (a chain is 66 feet), increasing the width of strips by cutting 2 chains windward and 1 chain leeward.

Gordon also is looking into seed production; noting stand damage from insects, diseases, and other causes; measuring the effects of solar radia-

tion on fir growth; and determining the composition of low-growing vegetation in true fir stands.

Two of Gordon's colleagues at Redding, research foresters William W. Oliver and Robert F. Powers, also are studying true fir. Oliver is trying to determine what the best stocking level is for wood production in young sawtimber stands of mixed red and white fir. Powers is doing research on the nutrient needs of white fir.

Entomologist George T. Ferrell of Berkeley is working with Robert F. Scharpf, a Station plant pathologist, on a risk-rating system. When completed, silviculturists and others can use the system to decide what the probability is that a given red or white fir will eventually succumb to attack by insects or diseases. The system will be based upon easily identified external characteristics, such as percentage of live crown, quality and quantity of cone crop, or condition of bark. The system should be ready for use in both young-growth and old-growth stands throughout the State by 1978.

The parasite dwarfmistletoe is a persistent and pervasive problem in California's true fir forests. Plant pathologist Scharpf is working on ways to reduce the amount of damage the parasite does in managed stands of second-growth fir.

With plant pathologists from the National Forests of California, Scharpf is doing an investigation of the impact populations of dwarfmistletoe have on red fir. And, with J. R. Parmeter, a UC Berkeley plant pathologist, Scharpf is studying the buildup and rate-of-spread of dwarfmistletoe in released red and white fir. As part of this project, Scharpf and Parmeter are doing research on the canker-forming fungus, *Cytospora abietis,* which often (but not always) grows on dwarfmistletoe swellings.

Berkeley geneticists M. Thompson Conkle, PSW Station; and William J. Libby, University of California, are trying to learn how family and geographic origin influence the growth of white fir. Their intent is to find out whether it is best to use seed from local sources, or seed from other forests, when planting California sites. The trees in their study were grown from seed collected in different parts of the white fir range—California, Oregon, and the Rocky Mountain States. These trees are now 12 years old and are located in five California plantations of different site quality, climate, and elevation.

▲ Twinned trees are susceptible to wind damage.

James L. Jenkinson, a plant physiologist with the Station in Berkeley, is evaluating the effect seed source has on growth of California red fir and white fir that are planted on high-elevation true fir sites. Jenkinson plans to compare the two species and hopes to determine how important geographic source and seed parent are. Seed collections for this study are from the Sierra Nevada populations of white fir, and from the Sierra Nevada and Cascade Range (California portion) populations of red fir. The first crop of test seedlings will be outplanted next spring in the Cascade-Sierra Nevada chain on six or more sites that are typical of California's commercial true fir lands.

In another new study, Jenkinson and Robert V. Bega, plant pathologist at PSW (Berkeley), are trying to find out when to fumigate nursery soil for protection of red and white fir planting stock, and how much fumigant to use. The nursery portion of their study is being done at the Forest Service's Placerville Nursery, located in the foothills of the west-side Sierra Nevada. According to Jenkinson, climatic conditions there are almost ideal for raising fir. However, the warm soil temperatures are conducive to root rots, which in turn are a threat to the young red and white fir. The problem of the fir's susceptibility to root diseases is compounded by the fact that both the firs need to

remain in most nurseries for two growing seasons before they are sturdy enough to outplant. This means that root-rot fungus established in fir during their first year can (and usually do) increase during the second nursery season.

At regular intervals, Bega and Jenkinson will check the fir seedlings in the nursery and later at the planting sites for any sign of root disease. Their work may help to increase the field survival of planting stock grown in the Placerville area, and should also aid nurserymen working in other regions where soil conditions are similar.

For this review of PSW research on the true firs, the PACFORNET service center in California (formerly CALFORNET—see *Forestry Research,* August, 1974) conducted a manual and a computer-based literature search of several data bases. These searches produced 3 informal bibliographies, totalling some 150 reports and publications that various agencies have prepared. The bibliographies are available from the Pacific Southwest Station. Ask for the PACFORNET FR5 package of bibliographies on red fir and white fir.

Among these entries are about 20 PSW Station reports. Some are recent; some are earlier publications that are still in demand.

## Seed maturity

One of the more recent reports is "Seed Maturity in White Fir and Red Fir," a paper in which William W. Oliver gives some tips on how to tell when fir seeds are ripe and ready to be collected. Seeds are probably mature, Oliver says, if the wings are an even brown, with a deep magenta trim along the outside edge; if the seeds themselves are free of—or are only loosely attached to—the cone scale; and if embryos are completely green and fill the entire embryo cavity. Details of this study are in Research Paper PSW-99-FR5.

In a paper issued earlier this year, entomologists George Ferrell and Ralph Hall say that if there is a slowdown in the growth rate of white fir, and a below-normal amount of precipitation, there may be an increase in the number of white fir killed by fir engraver or by roundheaded fir borer. More information on this study is in "Weather and Tree Growth Associated with White Fir Mortality Caused by Fir Engraver and Roundheaded Fir Borer," Research Paper PSW-109-FR5.

Also published this year is a Forest Pest Leaflet (146) on "*Cytospora* Canker of True Firs." Robert Scharpf of PSW co-authored this booklet with H. H. Bynum (formerly of the Rogue River National Forest, now deceased). They reported that the fungus, *Cytospora abietis,* exerts some degree of biological control over dwarfmistletoe, in that the fungus can establish itself on dwarfmistletoe-parasitized limbs and, within 6 months to 2 years, can girdle and kill the swollen branches. It's still not known whether this way of ridding a tree of dwarfmistletoe-invaded areas ends up increasing or decreasing the vigor of the tree. But, the authors suspect that *Cytospora* does more harm than good, and include in the Leaflet some tips on how to reduce damage from this disease. For copies, write the PSW Station.

## Experimental logging

An earlier paper worth a second look is Don Gordon's write-up of his experiments with release cuttings at the Swain Mountain Experimental Forest. In this report (Research Paper PSW-95-FR5) Gordon shows how effective release cuttings can be. Before the experimental logging at Swain Mountain, 39- to 45-year-old understory trees, 2.2 to 5 feet in height, were putting on only 0.1 to 0.2 foot in height per year. Five years after the release cuttings, however, most trees "were growing faster than before," Gordon states. Trees that were given the greatest amount of growing space made the most progress, increasing their growth rate an average of four times. What about the often-heard statement that both red and white fir grow very slowly for the first 30 or 40 years? It is probably true, Gordon says, for uncut stands where understories are suppressed and therefore unable to make the growth increases he documented at Swain Mountain.

The scientists doing true fir research are available to answer questions about their studies. Write to the Berkeley scientists at the PSW Station, P.O. Box 245, Berkeley, CA 94701, or phone (415) 486-3382 (after Dec. 1, FTS users phone 449-3382). For the Redding staff, write PSW Station, 1615 Continental Street, Redding, CA 96001, or phone (916) 246-5455 (FTS after Dec. 1 is 461-8455).

*—By Marcia Wood, Pacific Southwest Station*

# A recipe for cleaner campgrounds

Children in National Forest campgrounds throughout the Pacific Northwest have become litter fighters. These young anti-litterbugs are helping to reverse an expensive and highly objectionable trend. Instead of tossing a candy wrapper or empty can on the ground, the new generation picks up discarded trash, places it in a bag provided by the campground attendant, and turns the bag in for a well-earned reward.

Most observers agree that traditional approaches to controlling litter have not worked. The litter continues to build up, and campground workers spend long hours and public dollars cleaning up the debris.

In 1971, researchers in a Seattle unit of the Pacific Northwest Forest and Range Experiment Station began investigations into the control of litter. The PNW scientists, Roger Clark and John Hendee, together with Robert Burgess, a University of Washington sociologist, not only learned a lot about why people litter, but also developed and tested an incentive system aimed at solving the litter problem.

The initial research took place in two movie theaters in the Seattle area. Clark points out that movie theaters were an ideal starting point, because most moviegoers feel that it is okay to throw empty popcorn bags and boxes on the floor. Saturday matinees, with their large audience of children, were selected for the theater phase of research. Over a 14-week period, researchers handed out litter bags, increased the number of trash cans and made them more conspicuous, and showed a short film with a strong anti-litter message. Littering behavior was measured, in order to determine the response of the viewing audience to these traditional anti-litter measures. The results of this early work indicated that these conventional approaches did not work—almost half the litter remained on the floor.

In the next step, investigators implemented a system to reinforce anti-litter behavior. Children were offered several types of incentives for picking up trash and seeing that it was properly disposed of. With one group, the reward was a free ticket to a specially-scheduled matinee; with another test group, the award was one thin dime. The results of the incentive system were im- (continued on p. 8)

▲ The incentive system cuts litter about 75 percent.

pressive. Children in both test groups picked up more than 90 percent of the litter.

The Lake Kachess campground on the Wenatchee National Forest in Washington state was the scene for phase two of the research. Baseline data was again gathered in order to determine the amount and type of litter commonly found in the campground. The researchers then approached 26 children from seven camping families and asked if they would like to help in a litter pickup program.

The children were told that in exchange for picking up litter they would be able to choose from rewards such as a Smokey Bear comic book or shoulder patch, a Junior Forest Ranger badge, a small box of gum, a wooden ruler, or a "Keep Washington Green" pin. With litterbags clutched tightly in their small hands, the children worked through the campground. According to Clark, the results of this experiment and the many which followed suggested that litter can be reduced by about 75 percent when using this incentive system.

Campgrounds are obviously only a part of the total litter problem. Dispersed camping areas and hiking trails also accumulate litter. It was to one of these areas that the researchers next turned. Both the design of the study and the results were similar to the previous outdoor experiments. In the dispersed camping area, there was a 75 percent reduction from previous litter levels when the researchers offered incentives to the children of camping families.

Results such as those found by the PNW recreation research unit are of particular interest to land managers who face constantly rising costs and lower operating budgets. The practical applications of this simple incentive system have obvious esthetic and monetary advantages. Clark points out that an evaluation of one of the controlled experiments indicated that the incentive system was far more effective and much less costly than routine litter pickup by campground personnel. In one area, each bag of litter collected by Forest Service maintenance personnel cost about $8.30 in wages. Each bag of litter collected and turned in by one of the young volunteers cost about $0.50 in prizes. The time involved in contacting the families, lining up the children, and handing out the rewards is minimal. Both the money and manpower saved can be used for other important duties.

The litter incentive program has some other, not so obvious, benefits. Children who take part in the program leave their camping experience with at least the beginnings of a new environmental awareness. The small, inexpensive rewards, which are readily available at most Ranger Stations, are a reminder of why they were earned. Some of this awareness also rubs off on both Mom and Pop, who are also part of the litter program.

## *Slide-tape program*

The use of the litter incentive program has led to the development of some simple guidelines. According to Clark, the first contact should be with parents. Once the anti-litter campaign is explained, there is no problem in getting children to volunteer. The program seems to work best when the children are shown their incentives before beginning the litter pickup. Young children have been successfully teamed with older ones. These and other points are discussed and demonstrated in "The Incentive System for Litter Control," a 25-minute slide-tape program available from the Seattle research group (see address at end of article).

Since the initial research in 1971, Clark and his colleagues have been working with land managers from a variety of agencies to implement the program. The feedback from both the managers and the public has been very favorable and it appears that the incentive system is well on its way to becoming an established program.

The recipe for success in controlling campground litter is simple. Take the energy and interest of youth, mix it evenly with paper and cans, add a dash of incentive, and top the resulting mixture with a very small portion of your own time and budget.

Some publications on the subject include:

Burgess, Robert L., Roger N. Clark, and John C. Hendee. 1971. An Experimental Analysis of Anti-litter Procedures. *J. Appl. Behav. Anal.* 4(2):71-75.

Clark, Roger N., Robert L. Burgess, and John C. Hendee. 1972. The Development of Anti-litter Behavior in a Forest Campground. *J. Appl. Behav. Anal.* 5(1):1-5.

Clark, Roger N., John C. Hendee, and Robert L. Burgess. 1972. The Experimental Control of Littering. *J. Environ. Educ.* 4(2):22-28.

Clark, Roger N., John C. Hendee, and Randel F. Washburne. 1972. Litterbags: An Evaluation of Their Use. USDA Forest Serv. Res. Note PNW-184-FR5. 5 p.

For copies of these papers, or of the slide-tape program, write: Recreation Research Project, PNW Forest and Range Experiment Station, 4507 University Way, NE, Seattle, Washington 98105, or phone (206) 442-7817.

*—By Thomas M. Baugh, Pacific Northwest Station*

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# New program on timber use


On the Flathead National Forest in Montana, forest managers, scientists, and a timber company are cooperating in studies to find ways to harvest and utilize timber more efficiently without creating unacceptable impacts on the forest environment.

The studies, part of a special 5-year research and development program, are defining quantities and characteristics of wood residues, and evaluating harvesting and transportation systems to recover and use more of the residues.

R. L. Barger, manager of the program, says the research group is devoting a major part of their effort to monitoring the environmental impact of logging and associated activities.

Copies of "Skyline Logging, Close Timber Utilization, The Forest Environment," a brochure describing the studies, may be obtained by writing to the Intermountain Forest and Range Experiment Station, Ogden. □

◄ Large and small stems were removed in this sale.

# Surface mining poses questions

Coal provides energy people need. But people also need the forests, rangelands, and clean water above vast surface-minable coal deposits in the Western States.

From that dilemma spring complex questions for land managers. "How good are the chances for replacing surface vegetation after mining?" "What is the best rehabilitation method at this site?"

Forest Service researchers at the Intermountain Forest and Range Experiment Station are seeking answers to these questions—both on a broad scale and in specific studies. Much of the work is being done as part of the Forest Service's "SEAM" (Surface Environment and Mining) Program. The purpose of SEAM is to research, develop, and apply technology to maintain a quality environment while helping meet the nation's mineral and energy requirements.

Paul E. Packer, watershed project leader for the Intermountain Station at Logan, Utah, recently completed a study in the four-state area of the Northern Great Plains that contains most of the

▼ The Decker Coal Mine in southeastern Montana is the site of continuing research on revegetating surface-mined lands.

Nation's Federally-owned coal. He combined precipitation, soil, and plant characteristics in a system to predict how successful rehabilitation might be on lands that contain surface-minable coal and bentonite clay (an industrial filler material). He used the system to classify 4,062 square miles in Wyoming, Montana, North Dakota, and South Dakota into "rehabilitation-response units." The study encompassed 146 areas in 36 counties of the four-state region. At the time of his research, 22 surface coal mines and one bentonite mine were operating in the region.

Packer found that the rehabilitation potential of lands likely to be surface mined in this area ranges from fair to excellent if proper constraints are applied. He says factors that must be considered in predicting rehabilitation success include: (1) steepness of slopes; (2) effective disposition of toxic mine spoils; and (3) need for mulches, fertilizers, soil amendments, and irrigation water in restoring plant cover.

Sites with the highest rehabilitation potential generally are in west-central North Dakota where the best soils, the highest precipitation, and the largest variety of native plants suitable for revegetation occur. Intermediate sites are principally in southeastern Montana and extreme western North Dakota. Sites with the poorest rehabilitation potentials are in northeastern Wyoming and northeastern Montana, where soils are poor, precipitation is low, and native plants grow slowly and are difficult to obtain for large-scale plantings.

Packer learned that those parts of the Northern Great Plains with the most difficult rehabilitation problems are also the smallest areas that would have to be disturbed to extract a given amount of coal. He cautions that every site must be considered individually—all ecological and economic factors must be thoroughly examined to determine the feasibility and desirability of surface mining. A complete description of Packer's findings is in the publication, "Rehabilitation Potentials and Limitations of Surface-Mined Land in the Northern Great Plains," General Technical Report INT-14-FR5.

First-year results of a specific study to find the most efficient way to provide acceptable plant cover on surface-minded lands are available in a report by Eugene E. Farmer, Ray W. Brown, Bland Z. Richardson, and Paul E. Packer. The results are guiding continuing research on revegetating


▲ Research plots are located on graded mine spoils.

surface-mined lands at the Decker Coal Mine in southeastern Montana. The Decker Mine is expected to develop into one of the largest surface coal mines in the United States. The research plots provided the knowledge necessary to establish rehabilitation demonstration areas. The demonstration areas are open to industry and the public.

In the Decker research, plots are located on graded mine spoils created in reaching coal deposits 60 feet below the surface. Grass seed mixtures, and seed mixtures with fertilizer, mulch, or both, were applied to irrigated and unirrigated plots, and to plots with and without added topsoil. The first-year results show that grass on the plots with topsoil, regardless of mulch or fertilizer, grew best. Several other combinations produced acceptable grass stands.

If you'd like to know more about the Decker research, request "Revegetation on the Decker Coal Mine in Southeastern Montana," Research Paper INT-162-FR5, from the Intermountain Station.

*—By Dick Klade, Intermountain Station*

# Publications

▲ Giant cedars—one of Montana's forest resources.

## Montana forests analyzed

Competing demands for forest land are forcing a clearer definition of the alternatives for reaching both commodity and environmental objectives. "A Descriptive Analysis of Montana's Forest Resources," recently published by the Intermountain Forest and Range Experiment Station, helps define those alternatives. Authors are Dennis L. Schweitzer, forest economist, and Robert E. Benson, research forester, both of the Intermountain Station; and Richard J. McConnen, head of the Department of Economics and Agricultural Economics at Montana State University, Bozeman.

One-fourth of the State is forest land—about 23 million acres in all. About 75 percent of the forest land is federally owned and most of the rest is in private ownership. Currently there is a widespread interest in how these lands are used and managed. They play a significant role in Montana's economy, and their use greatly influences the environmental quality of much of the State.

The analysis updates a 1959 report on the use and development of timber resources in Montana. The authors have expanded the scope and content by including data on employment, income, and economics. In addition, they describe amenity values of critical importance in forest land use management.

The extent to which Montana's forest lands will provide timber in the future hinges both on the extent of the land base that will be devoted to timber production and the quantities of wood harvested from that base. Although the total area of forest land has remained almost constant during the last 20 years, the principal timber-producing acreage has decreased as a result of environmental, recreation, and other concerns.

There are hundreds of millions of board feet of timber in unroaded areas of Montana. Reserving a large portion of those areas from harvesting would have substantial impacts on the State's economy.

Two principal conclusions stand out. First, Montana no longer has a large surplus of timber awaiting a market. Second, there is sharp competition for currently available wood supplies. The economic values of the timber resource are important to Montana and are critical to many individual communities, especially in western Montana. But the vitality of the industry is dependent upon national economic conditions and national markets that are beyond the State's control.

The analysis illustrates the challenge posed to forest resource managers by ex-

panded interest in environmental protection, conflicts among forest users, and intense competition for wood supplies. The authors hope their report will be a step toward resolving the conflicts between users of forest land.

Copies of the report, Resource Bulletin INT-11-FR5, are available from the Intermountain Station.

## Nitrogen for Douglas-fir

Research continues to show the value of nitrogen fertilizer for speeding the growth of the Douglas-fir forest. The most recent evidence is a study of the Wind River Experimental Forest in southwestern Washington, where ammonium nitrate has improved growth of trees in a 37-year-old Douglas-fir plantation. The trees were growing on a poor site that was deficient in nitrogen. Fertilizer was applied at rates of 140, 280, and 420 pounds per acre.

Four years after fertilization, substantial increases were reported in height, diameter, and basal area (see "Growth Response of 35-year-old, Site V Douglas-fir to Nitrogen Fertilizer," Research Note PNW-86-FR5, by Donald L. Reukema). Seven years after treatment, the benefits from fertilizing were still apparent. For example, trees averaged 2.3 inches more in diameter on the most heavily fertilized plots. And, height growth in these plots averaged 7.1 feet, or 89 percent more than growth on the unfertilized plots.

Maximum gain in growth, however, occurred on the sites treated with 280 pounds of fertilizer. One reason for this was the high incidence of snow breakage to smaller trees on the most heavily fertilized plots. Apparently, better nutrition resulted in longer needles, which in turn increased wind resistance and the accumulation of snow on branches. The mortality of trees treated with 280 and 420 pounds of nitrogen was twice as great as that which occurred on the unfertilized or the lightly fertilized (140 pounds per acre) plots. This doesn't mean you shouldn't use the higher dosage: It means you should be careful where and how it is applied. For example, in areas prone to winter breakage, foresters may need to adjust nitrogen dosage.

An additional benefit can be obtained by combining fertilization with thinning, especially in young, natural stands on low-quality sites. In this way, increased growth can be concentrated on fewer trees.

See "Seven-year Response of 35-year-old Douglas-fir to Nitrogen Fertilizer," Research Paper PNW-165-FR5, by R. E. Miller and L. V. Pienaar.

## Scotch pine report

Rocky Mountain Station scientists in the Great Plains are searching for trees that will grow well in that harsh environment. Scotch pine holds promise of being such a tree.

Richard A. Cunningham and Ralph A. Read have published reports on growth rate, form, and winter foliage color of Scotch pine grown from seed collected across Europe and northern Asia. Cunningham, now with Forest Service Region 2, Denver, was formerly associate plant geneticist at Bottineau, North Dakota; Read is principal silviculturist at Lincoln, Nebraska.

Seedlings from 49 seed sources were planted in North Dakota in the early sixties. Cunningham ("Scotch Pine for the Northern Great Plains," Research Paper RM-114-FR5) reports that trees from central Russian and Ural Mountain sources appear best suited for Northern Great Plains shelterbelts. Though winter foliage turns yellow-green, these trees grow rapidly while retaining satisfactory crown density and good survival rates, essential features in shelterbelt development. Seed from Turkey produces slower growing trees with dense, uniform crowns and year-round blue-green foliage, ideal Christmas tree characteristics.

In 1962 Read established a plantation in Nebraska from 36 European and Asian seed sources ("Scots Pine in Eastern Nebraska: A Provenance Study," Research Paper RM-78-FR5). The best Christmas trees grew from seed origins in southern latitudes, such as Turkey, Spain, and southern France. Seed from Belgium and the Vosges Mountains of France and Germany yielded trees high in desired characteristics for Central Great Plains shelterbelt planting. Read also noted that northern European and northern Siberian trees, which turn yellow in winter, may prove useful for ornamental purposes where color contrast is desired.

## Elk and timothy grass

Using fertilizers to stimulate the growth of grass in clearcut areas may provide unexpected benefits for wildlife. Scientists at the PNW Station's Range and Wildlife Habitat Laboratory in La Grande, Oregon, reported on this subject in *Rangeman's Journal.* The authors of " 'Yukky to Yummy'—with Fertilizers" are J. Michael Geist, Paul Edgerton, and Gerald Strickler.

The three scientists based a field study of fertilization on laboratory findings which indicated that nitrogen and sulfur aided the growth of timothy grass on volcanic ash soils. The 36-acre plot used in the study had been clearcut and the slash had been burned. Ten-by-fifteen-foot subplots were then treated with different fertilizers in varying amounts or were left unfertilized.

Although elk were known to use the area, the scientists didn't feel this would have any significant effect on their study. Past experience had shown that elk only grazed timothy grass when other preferred forage was not available.

But as soon as the timothy grass began to grow, the elk started to graze the fertilized plots. The type of fertilizer didn't seem to matter and the researchers were able to rule out increased protein as a possible attractant.

The scientists are the first to admit that their unexpected research results are "fragmentary" and that additional study would be necessary before they could recommend this practice to increase forage for elk. But it certainly is worth studying further, and may be worth trying in some situations.

Reprints of the December, 1974, article may be obtained from the Pacific Northwest Forest and Range Experiment Station.

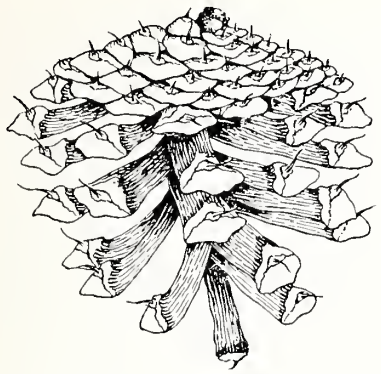
## Quick test of sagebrush

Sagebrush is just sagebrush to most people, but to mule deer and game managers in the Intermountain area, it comes in 20 or more flavors. Deer eat only about half of two dozen types in the Intermountain area—with a distinct preference for the Vasey big sagebrush (*Artemisia tridentata* subsp. *vaseyana*).

A technique has been developed by Richard Stevens, a game biologist of the Utah Division of Wildlife Resources, and E. Durant McArthur, research geneticist, Intermountain Forest and Range Experiment Station, that provides an on-the-spot field test that game managers can use to quickly identify the Vasey big sagebrush. An inexpensive mineral light, similar to those used by rockhounds, is the only piece of equipment required.

Mineral light identification is simple: The user merely crushes some sagebrush leaves in a small dish, or in the palm of his hand, and adds a little water. Next, he finds a dark place, and turns the light on the leaves. If the color is an intense blue, he has found one of the deer's favorites, because all taxa producing blue water extracts are preferred by mule deer.

Reprints of "A Simple Field Technique for Identification of Some Sagebrush Taxa" (*Journal of Range Management* 27(4):325-326) are available from the Intermountain Forest and Range Experiment Station, Ogden.



## Shoot moth attractant

Another insect has recently joined the growing list of forest pests that may be controlled with the help of pheromones or sex attractants. This time it is the European pine shoot moth, an imported pest of pine forests.

Forest Service entomologists, and chemists from the Oregon Graduate Center in Portland, Oregon, have identified the chemical nature of the moth's attractant, duplicated it in the laboratory, and tested it successfully there and in the field. The chemical, (E)-9-dodecenyl acetate, is now being used in survey programs to locate infestation centers in the Pacific Northwest.

The pine shoot moth is of special concern because it attacks young trees and could be a major threat to pine plantations. The shoot moth was introduced to the Eastern United States in 1914 and was first reported in the West in 1959. So far, its tour of the West has been limited to ornamentals, commercial nurseries, and Christmas tree plantations. Although strict quarantine methods are enforced, the moth could work its way into the woods. But use of the new artificial attractant reduces the chance that the shoot moth will ever get a firm foothold in western pine forests.

Read all about it in "Sex Pheromone of the European Pine Shoot Moth: Chemical Identification and Field Tests," by Ronald G. Smith and others (Daterman, Daves, McMurtrey, and Roelofs), a reprint from *Insect Physiology,* 20(4):661-668.

## Christmas tree study

When you take your family to a sales lot to buy your Christmas tree this year, you will probably go through the lot again and again, searching for the "perfect tree." Finally, after your feet are blocks of ice, the family will agree on one that will give your home the "Christmas card" look.

If you live in the Intermountain States, chances are the tree you selected was a Douglas-fir, king of the Christmas tree industry in the northern Rockies. In the last three decades, practically all of the more than 80 million Christmas trees grown in Montana, for example, were Douglas-fir.

Inherent in Douglas-fir are many desirable qualities—good retention of the soft, short needles, a deep green color, and a pleasant aroma. But this is still not enough for the average buyers. They want their trees to be uniform in shape, and certainly the trees must have nice, thick crowns.

The Christmas tree grower in the northern Rockies isn't very happy about such discrimination among buyers. Most of the grower's crop comes from natural, wild stands. All you have to do is walk through a stand of trees in a forest to realize that the "perfect tree" is a rarity. This grower is taking a beating in the market. Montana's share of the Christmas tree market has dropped to less than half of the level it was during the 1940's. One of the biggest reasons for this decline is that buyers are purchasing trees harvested from cultured stands, where the most desirable qualities can be carefully nurtured.

Deciding that, "If you can't lick 'em, join 'em," the tree producers of the northern

Rockies are now using various cultural methods in the natural stands of Douglas-fir. However, many growers are uncertain whether they are benefiting from such methods and are uncertain which methods will yield the greatest number of marketable trees.

The Intermountain Forest and Range Experiment Station has published the results of a 10-year study of three commonly-used Christmas tree culture methods. Wyman C. Schmidt, silviculturist, reported in "Christmas Tree Culture in Natural Stands of Douglas-fir in Montana," that the quantity and quality of trees can be increased with planned stocking, basal pruning, and thinning. For more information, write to the Intermountain Station for copies of Research Paper INT-84-FR5.

▼ Douglas-fir on Montana's Helena National Forest.

## *Watersheds of the Rockies*

Researchers at the Rocky Mountain Station have completed six "status-of-our-knowledge" papers on watershed management research in the Rocky Mountains of Wyoming, Colorado, and New Mexico, and the Black Hills of South Dakota. This information was previously scattered throughout numerous articles, publications, and notes. Much of it had never been documented in the literature. The new papers synthesize and organize 40 years of published and unpublished results into one series.

Each of the first five papers cover a vegetation type, or geographic area, important to water yield and quality. The authors describe: (1) what is known about the hydrology of principal vegetation zones and (2) how this knowledge can best be applied to meet multi-resource management objectives. They also include a thorough reference list. A sixth paper summarizes the series.

### *Alpine areas, subalpine zone*

Research meteorologist Mario Martinelli, Jr., of Fort Collins, Colorado, says in his report (Research Paper RM-138, "Water-Yield Improvement from Alpine Areas") little can be done to increase the volume of annual streamflow from mountains above timberline. These watersheds naturally yield up to 90 percent of the moisture they receive as rain and snow. What can be changed, however, is the time of year snowmelt is released to streamflow.

Martinelli describes the potential for using snow fences or other types of structures to deepen natural snowdrifts. This practice retards snowmelt until later in the summer when there is greater need for water downstream. He also points out how fences can be used to reduce hazards such as the build-up of snow in avalanche starting zones or the drift of snow across mountain highways.

Charles E. Leaf, formerly a research hydrologist at Fort Collins, Colorado, is the author of Research Paper RM-137, "Watershed Management in the Rocky Mountain Subalpine Zone." Leaf says patchcutting to create small openings over 40 percent of a densely forested subalpine watershed may increase annual water yield by 25 percent. With careful planning, a timber harvest can create a pattern of openings that enhances esthetics, wildlife habitat, and timber production.

Leaf and his associates have developed a computer model land managers can use to predict how alternative management proposals will affect water and timber resources.

## Ponderosa pine zone

"Watershed Management Problems and Opportunities for the Colorado Front Range Ponderosa Pine Zone" (Research Paper RM-139) is Howard L. Gary's contribution to the series. Gary, a research forester at Fort Collins, Colorado, suggests some water yield improvement can be obtained in the ponderosa pine zone by following the patchcutting procedures suggested for the subalpine forest. Gary warns that minimum amounts of litter and vegetation must be left on the ground to protect the watershed, but adds that even the best management practices can't prevent geologic processes which are characteristic of the Front Range. He also points out the threat to water quality posed by rapid development of second homes, new communities, and recreation complexes in the Zone.

## Mountain sagebrush lands

David L. Sturges, a research forester at Laramie, Wyoming, wrote the summary on mountain sagebrush lands ("Hydrologic Relations on Undisturbed and Converted Big Sagebrush Lands," Research Paper RM-140). Sturges says a potential exists for increasing water yield by as much as 13 percent from sagebrush lands above 7,000 feet in elevation. This requires removal of sagebrush and conversion of ground cover to grass which uses less water. Forage for livestock can be improved by this practice. To avoid erosion, techniques that cause minimal soil disturbance should be used.

Snow fences can be constructed in key locations to trap drifting snow and augment local water supplies.

## The Black Hills, summary

According to Howard K. Orr, a research forester at Rapid City, irregular patchcutting may increase water yield upstream from sedimentary geologic formations that ring the Hills. This is one of the observations he makes in "Watershed Management in the Black Hills," Research Paper RM-141.

Orr points out that old roads, mining activities, and new developments are the greatest threats to water quality in the Hills. These can easily be controlled, however, through proper land rehabilitation and engineering design.

For administrators and supervisors, Charles Leaf has prepared a summary of the five other papers. It is "Watershed Management in the Central and Southern Rocky Mountains: A Summary of the Status of Our Knowledge by Vegetation Types" (Research Paper RM-142). Administrators will find this résumé provides key hydrologic and watershed management facts helpful to them as they make land management decisions.

All of these papers may be obtained by writing to the Rocky Mountain Station. However, bulk supplies of the summary paper (Research Paper RM-142) must be ordered from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (please give title, specify stock number 001-001-00398, and enclose $0.80 per copy).

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